

1 **WHAT IS CLAIMED IS:**

2 1. An apparatus for programmably manipulating a packet, said apparatus comprising:

3 a reaction surface configured to provide an interaction site for said packet;

4 an inlet port coupled to said reaction surface and configured to introduce said
5 packet onto said reaction surface;

6 means for generating a programmable manipulation force upon said packet to
7 programmably move said packet about said reaction surface along
8 arbitrarily chosen paths; and

9 a position sensor coupled to said reaction surface and configured to sense a
10 position of said packet on said reaction surface; and

11 a controller coupled to said means for generating a programmable manipulating
12 force and to said position sensor, said controller configured to adjust said
13 programmable manipulation force according to said position.

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15 2. The apparatus of claim 1, further comprising an outlet port coupled to said reaction
16 surface and configured to collect said packet from said reaction surface.

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18 3. The apparatus of claim 1, wherein said means for generating a manipulation force
19 comprises a conductor adapted to generate an electric field.

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21 4. The apparatus of claim 1, wherein said means for generating a manipulation force
22 comprises a light source.

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24 5. The apparatus of claim 1, wherein said manipulation force comprises a
25 dielectrophoretic force, an electrophoretic force, an optical force, a mechanical force, or
26 any combination thereof.

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28 6. The apparatus of claim 1, wherein said position sensor comprises a conductor
29 configured to measure an electrical impedance of said packet.

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2 7. The apparatus of claim 1, wherein said position sensor comprises an optical system
3 configured to monitor said position of said packet.

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5 8. The apparatus of claim 1, wherein said means for generating a programmable
6 manipulation force and said position sensor are integral.

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8 9. An apparatus for microfluidic processing by programmably manipulating packets, said
9 apparatus comprising:

10 a reaction surface configured to provide an interaction site for said packets;

11 an inlet port coupled to said reaction surface and configured to introduce said
12 packets onto said reaction surface;

13 an array of driving electrodes coupled to said reaction surface and configured to
14 generate a programmable manipulation force upon said packets to direct
15 said microfluidic processing by moving said packets along arbitrarily
16 chosen paths; and

17 an array of impedance sensing electrodes coupled to said reaction surface and
18 configured to sense a position of said packets during said microfluidic
19 processing.

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21 10. The apparatus of claim 9, further comprising an outlet port coupled to said reaction
22 surface and configured to collect said packets from said reaction surface.

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24 11. The apparatus of claim 9, further comprising a controller coupled to said array of
25 driving electrodes and to said array of impedance sensing electrodes, said controller
26 adapted to provide a feedback from said array of impedance sensing electrodes to said
27 array of driving electrodes.

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29 12. The apparatus of claim 9, wherein said array of driving electrodes and said array of
30 impedance sensing electrodes are integral.

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13. The apparatus of claim 9 further comprising an integrated circuit coupled to said array of driving electrodes and to said array of impedance sensing electrodes.

14. The apparatus of claim 9 further comprising a coating modifying a hydrophobicity of said reaction surface.

15. The apparatus of claim 9, further comprising a maintenance port.

16. An apparatus for processing packets in a partitioning medium, said apparatus comprising:

- a chamber configured to contain said packets and said partitioning medium;
- a programmable dielectrophoretic array coupled to said chamber and configured to generate a programmable dielectrophoretic force to direct processing of said packets; and
- an impedance sensing array of electrodes integral with said programmable dielectrophoretic array, said impedance sensing array of electrodes configured to sense a position of said packets within said chamber.

17. The apparatus of claim 16, further comprising an integrated circuit coupled to said programmable dielectrophoretic array and to said impedance sensing array of electrodes.

18. The apparatus of claim 16, further comprising a controller coupled to said programmable dielectrophoretic array and to said impedance sensing array of electrodes, said controller adapted to provide a feedback from said impedance sensing array of electrodes to said programmable dielectrophoretic array.

19. The apparatus of claim 16, wherein said electrodes are between about 1 micron and about 200 microns and are spaced between about 1 micron and about 200 microns.

1 20. A method for manipulating a packet, comprising:

2 providing a reaction surface, an inlet port coupled to said reaction surface, means
3 for generating a programmable manipulation force upon said packet, a
4 position sensor coupled to said reaction surface, and a controller coupled
5 to said means for generating a programmable manipulation force and to
6 said position sensor;

7 introducing a material onto said reaction surface with said inlet port;

8 compartmentalizing said material to form said packet;

9 sensing a position of said packet with said position sensor;

10 applying a programmable manipulation force on said packet at said position with
11 said means for generating a programmable manipulation force, said
12 programmable manipulation force being adjustable according to said
13 position by said controller;

14 programmably moving said packet according to said programmable manipulation
15 force along arbitrarily chosen paths.
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17 21. The method of claim 20, wherein said packet comprises a fluid packet, an
18 encapsulated packet, or a solid packet.
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20 22. The method of claim 20, wherein said compartmentalizing comprises suspending
21 said material in a partitioning medium.
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23 23. The method of claim 22, wherein said material is immiscible in said partitioning
24 medium.
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26 24. The method of claim 22, wherein said reaction surface includes a coating, and a
27 hydrophobicity of said coating is greater than a hydrophobicity of said partitioning
28 medium.
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1 25. The method of claim 20, wherein said applying a programmable manipulation force
2 comprises applying a driving signal to one or more driving electrodes arranged in an
3 array to generate said programmable manipulation force.

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5 26. The method of claim 20, wherein said programmable manipulation force comprises a
6 dielectrophoretic force, an electrophoretic force, an optical force, a mechanical force, or
7 any combination thereof.

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9 27. The method of claim 20, wherein said sensing a position comprises applying a
10 sensing signal to one or more impedance sensing electrodes arranged in an array to detect
11 an impedance associated with said packet.

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13 28. The method of claim 20, further comprising interacting said packet, wherein said
14 interacting comprises moving, fusing, merging, mixing, reacting, metering, dividing,
15 splitting, sensing, collecting, or any combination thereof.

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17 29. A method of fluidic processing, said method comprising:

18 providing a reaction surface, an inlet port coupled to said reaction surface, an
19 array of driving electrodes coupled to said reaction surface, and an array of
20 impedance sensing electrodes coupled to said reaction surface;

21 introducing one or more materials onto said reaction surface with said inlet port;

22 compartmentalizing said one or more materials to form a plurality of packets;

23 applying a sensing signal to one or more of said impedance sensing electrodes to

24 determine a position of one or more of said plurality of packets; and

25 applying a driving signal to one or more of said driving electrodes to generate a

26 programmable manipulation force on one or more of said plurality of

27 packets at said position; and

28 interacting one or more of said plurality of packets according to said

29 programmable manipulation force.
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1 sensing a position of said one or more packets with said impedance sensing array
 2 of electrodes;
 3 monitoring whether said position corresponds to said path; and
 4 interacting said one or more packets.

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 6 37. The method of claim 36, wherein at lease one of said one or more packets comprises
 7 a fluid packet, an encapsulated packet, or a solid packet.

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 9 38. The method of claim 36, further comprising:
 10 sensing a position of an obstruction;
 11 determining a modified path, said modified path avoiding said obstruction; and
 12 applying a programmable manipulation force on said one or more packets to move
 13 said one or more packets along said modified path.

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 15 39. The method of claim 36, wherein said specifying a path comprises specifying an
 16 initial position and a final position.

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 18 40. The method of claim 36, wherein said introducing a material comprises extracting
 19 said material with a dielectrophoretic extraction force from an injector onto said reaction
 20 surface.

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 22 41. The method of claim 36, wherein said interacting comprises moving, fusing,
 23 merging, mixing, reacting, metering, dividing, splitting, sensing, collecting, or any
 24 combination thereof.